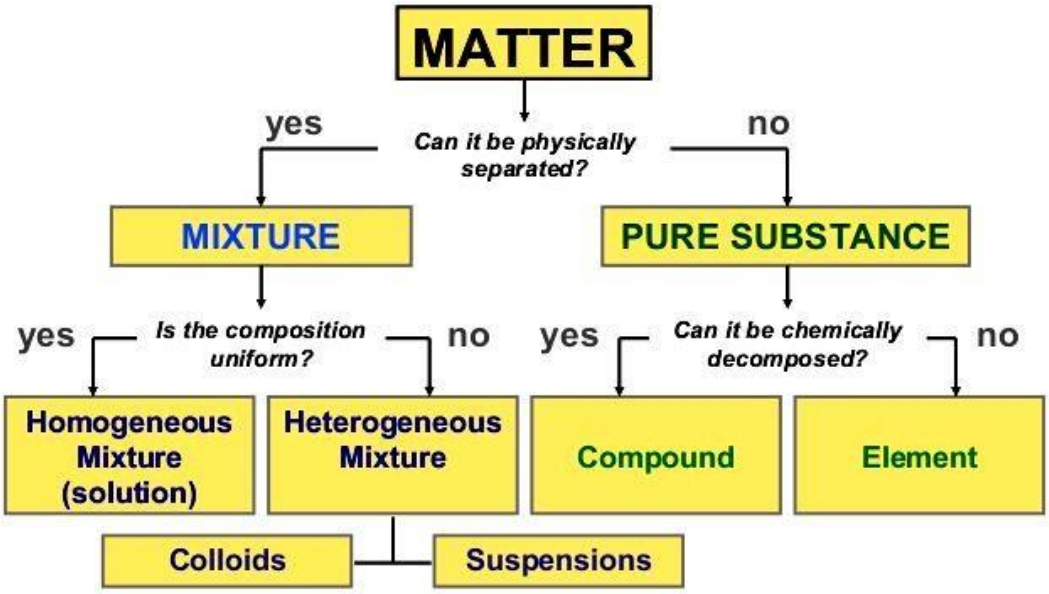
Chapter 3 - ELEMENTS, COMPOUNDS AND MIXTURE

Subtopic :

Matters can be classified into two types – Pure substances and Impure substances.
Pure substances – Pure substances are of two types – Elements and Compounds.
Impure substances – All mixture are considered as impure substances.

Colour, odour, density, melting point and boiling point are often treated as physical properties of matter. The physical properties of a substance can be observed or measured without changing its composition.

The term " impure" is different from adulteration. According to scientists, the term " pure" means single form of matter.



Most of the substances in our surroundings are not in their pure form and are called mixture. Substances which are made of two or more matters and which can be separated by physical methods are known as mixtures, such as mixture of salt and water, mixture of sugar and water, mixture of different gases, air, etc.

In a mixture, components do not combine chemically or through any chemical change. In a mixture, components do not lose their properties.

Mixtures are of two types on the basis of their composition - Homogeneous mixture and Heterogeneous mixture.

HOMOGENEOUS MIXTURE

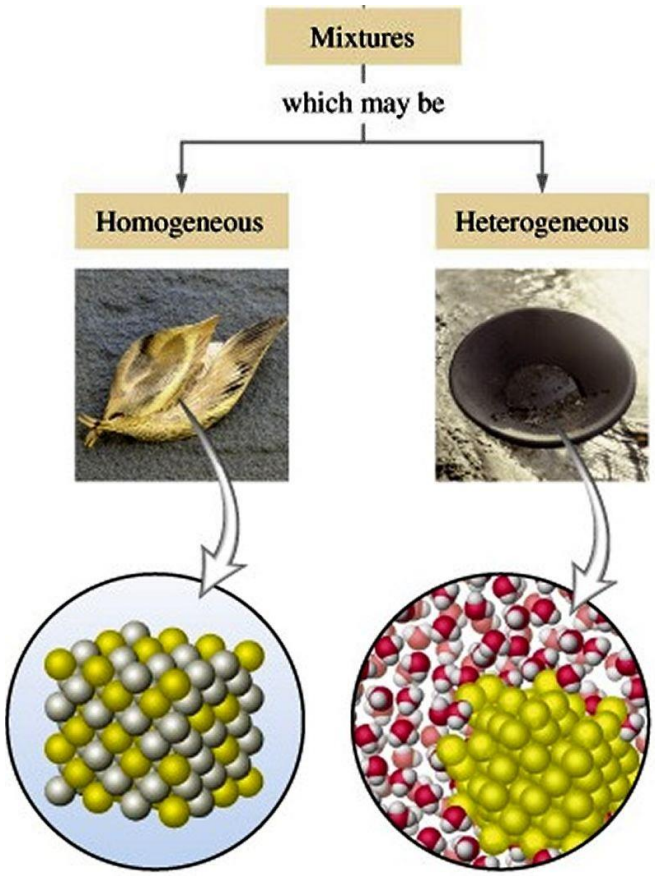
Mixtures which have uniform composition throughout are called Homogeneous Mixture. For example – mixture of salt and water, mixture of sugar and water, air, lemonade, soda water, etc.

Mixture of salt in water is an example of homogeneous mixture. In this mixture, the boundary of salt and water cannot be differentiated. When a ray of light is passed through the mixture of salt and water, the path of light is not seen.

General Properties of Homogeneous Mixture:

- All solutions are the examples of homogeneous mixture.
- The particles of a homogeneous mixture are less the one nanometer.

- A homogenous mixture does not show Tyndall effect.
- The boundaries of particles cannot be differentiated.
- The constituent particles of homogenous mixture cannot be separated using centrifugation or decantation.
- Alloys are the examples of solution.



HETEROGENEOUS MIXTURE

Mixtures which do not have uniform composition throughout are called Heterogeneous Mixture. For example – mixture of soil and sand, mixture of sulphur and iron fillings, mixture of oil and water etc. The boundaries of constituent particles of a homogeneous mixture can be identified easily; as a homogeneous mixture has two or more distinct phases.

General Properties of Heterogeneous Mixture:

- Most of the mixtures are heterogeneous except solutions and alloys.
- The constituent particles are present uniformly in a heterogeneous mixture.
- The components of a heterogeneous mixture can be identified easily.
- Generally, two or more phases are present in a heterogeneous mixture.
- Particles of a heterogeneous mixture are sized between one nanometer and one micrometer or more.
- Heterogeneous mixtures show Tyndall effect.

Subtopic :

PURE SUBSTANCES

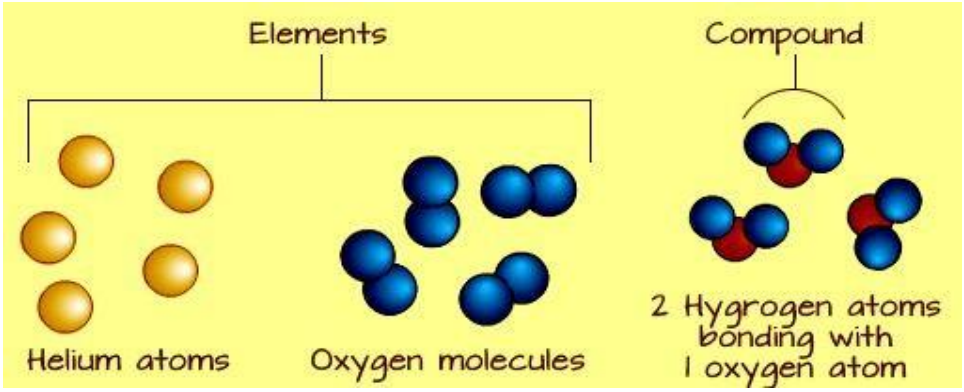
Elements and Compounds are considered as pure substances.

Elements – Substances that is made of only one element are called elements, such as hydrogen, carbon, oxygen, silver, gold, etc.

Elements can be normally divided into metals, non-metals and metalloids. Metals usually showsome or all of the following properties:

- They have a lustre (shine).
- They have silvery-grey or golden-yellow colour.
- They conduct heat and electricity.
- They are ductile (can be drawn into wires).
- They are malleable (can be hammered into thin sheets).
- They are sonorous (make a ringing sound when hit).

Examples of metals are gold, silver, copper, iron, sodium, potassium etc. Mercury is the only metal that is liquid at room temperature.



Non-metals usually show some or all of the following properties:

- They display a variety of colours.
- They are poor conductors of heat and electricity.
- They are not lustrous, sonorous or malleable.

Examples of non-metals are hydrogen, oxygen, iodine, carbon (coal, coke), bromine, chlorine etc. Some elements have intermediate properties between those of metals and non-metals, they are called metalloids; examples are boron, silicon, germanium etc.

Compounds – Substances that is made of one or more elements by chemical combination are called compounds, such as water, carbon dioxide, copper oxide, hydrochloric acid, etc.

A compound does not contain the properties of its constituent elements and shows quite different characteristics.

COMPARISON BETWEEN COMPOUND AND ELEMENT

	Compound	Element
Distinguishing Feature	Compounds contain different elements in a fixed ratio arranged in a defined manner through chemical bonds.	Elements are distinguished by their atomic number (number of protons in their nucleus).
Ability to Breakdown	A compound can be separated into simpler substances by chemical methods/reactions.	Elements cannot be broken down into simpler substances by chemical reactions.
Types	The list of compounds is endless.	There are about 117 elements that have been observed. Can be classified as metal, non-metal or metalloid.
Representation	A compound is represented using a formula.	An element is represented using symbols.
Examples	Water (H_2O), Sodium chloride (NaCl), Sodium bicarbonate ($NaHCO_3$) etc.	Iron, copper, silver, gold, nickel etc.

Mixture	Compound
Elements are physically mixed in any ratio and no new compound is formed.	Elements are chemically combined in a fixed ratio to form a new compound.
They have no sharp or definite melting point, boiling point, density etc.	They have definite melting point, boiling point, density etc.
A mixture exhibits the properties of its constituent or component elements.	Property of a compound is different from its constituent or component elements.
They are either homogeneous or heterogeneous in nature.	They are always homogeneous in nature.
Constituents of a mixture can be separated by physical methods like filtration, magnetic separation etc.	Constituents of a compound cannot be separated by physical methods.

Subtopic :

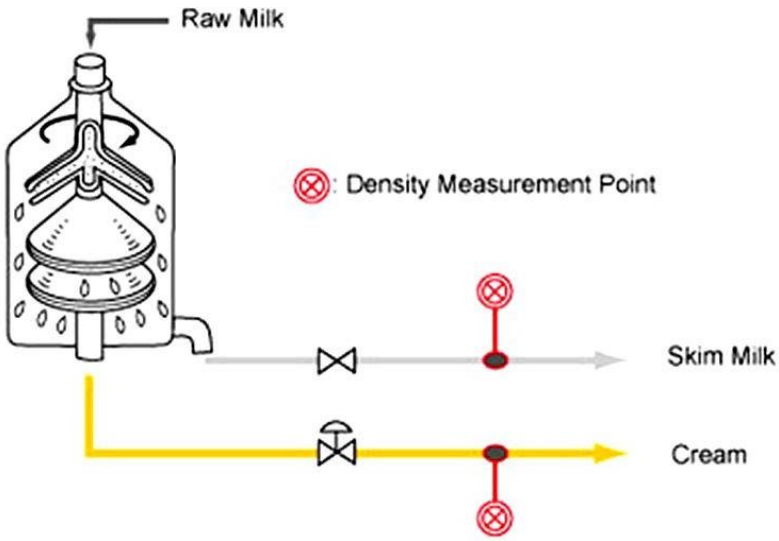
SEPARATION OF COMPONENTS OF MIXTURE

CENTRIFUGATION

In the method of centrifugation, the centripetal and centrifugal forces are used to separate lighter and heavier components of mixture of two immiscible liquids. This process is used to separate very small solids particles from a liquid mixture.

Example – Milk is the mixture of fat, water, and other constituents. Using the method of centrifugation, most of the fat can be separated from milk. In milk, fat is suspended throughout the milk which is separated out using the method of centrifugation.

When milk is churned rapidly, water which is heavier than fat, migrates away from the centre of centrifuge while fat is forced towards the bottom, which is drained out.



Application of centrifugation –

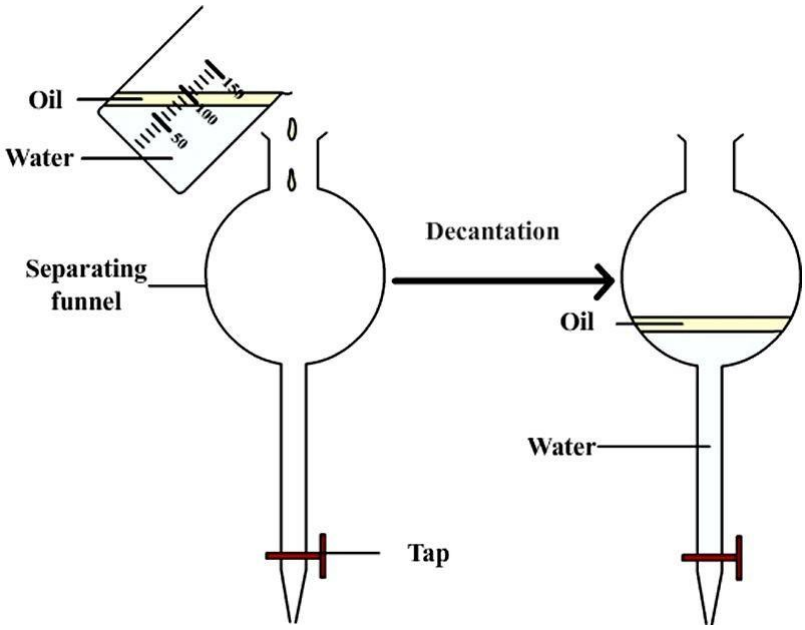
- In pathological test of blood and urine.
- In separation of fat from milk.
- In washing machines to squeeze the water from wet clothes.

DECANTATION

Decantation is used to separate the components from a mixture of two immiscible liquids, such as mixture of oil and water. In a mixture of two immiscible liquids, lighter one and heavier one form separate layer. The lighter one can be decanted after settling of mixture, carefully in other container.

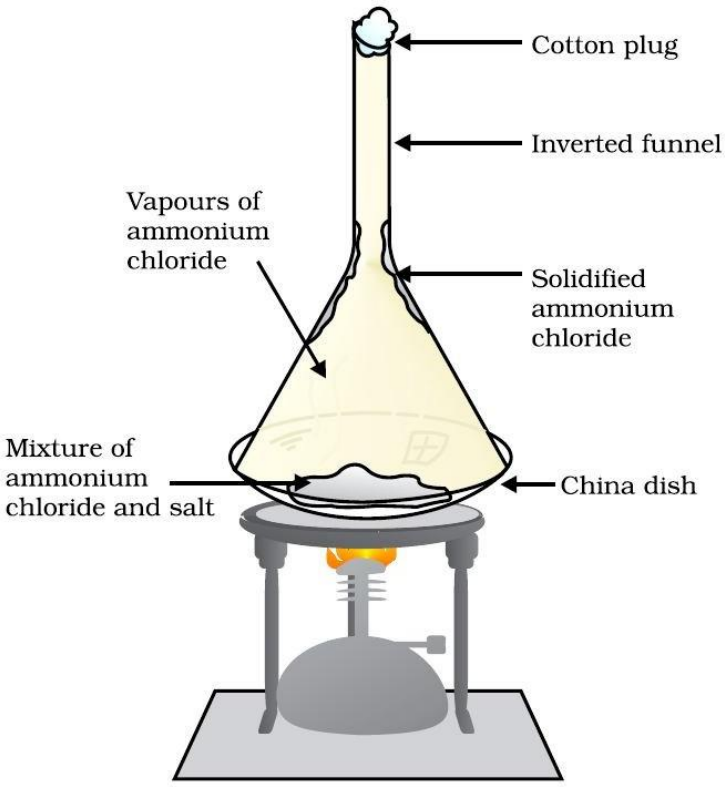
In the process of decantation some of the heavier liquid also poured out with lighter one. Therefore, components from a mixture of two immiscible liquids; can be separated more easily and accurately using a separating funnel.

A separating funnel is usually made of glass with a stop cork with drain pipe at bottom. The heavier liquid which is settled at bottom is drained out from the mixture of two immiscible liquids by opening of stop cork from a separating funnel.


Oil
Water
150
100
50
Separating funnel
Decantation
Oil
Water
Tap

SUBLIMATION

There are many substances which are converted into gas from solid when heated, and converted from gas to solid when cooled without converting into liquid. Such substances are known as sublime. For example – ammonium chloride, naphthalene balls, camphor, etc. Therefore, mixture of one sublime and other substance can be separated using the method of sublimation.



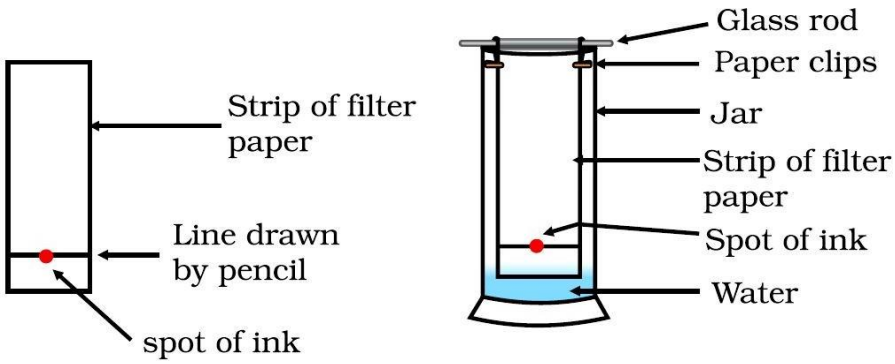
The mixture of ammonium chloride and common salt can be separated out using the process of sublimation. For this, the mixture is heated in a China dish. The China dish is covered by an inverted funnel. Cotton is used for plugging the opening of the funnel. After heating, ammonium chloride is converted into vapour and gets deposited over the inner surface of funnel; due to cooling. This leaves the common salt in China dish. Ammonium chloride can be taken out by scratching from the inner wall of funnel.

CHROMATOGRAPHY

Chromatography is a method of separation which works on the principle of travel speed of components of a mixture. This method is used for separating dyes and pigments from a mixture. Ink is the mixture of dyes of different colours.

There are many types of chromatography. The dyes from an ink can be separated using paper chromatography.

For this, a strip of filter paper is dipped in the ink. Particles of dye start rising on filter paper; along with water. Different dyes rise with different speed because of different types of solubility in water and go up to certain heights.

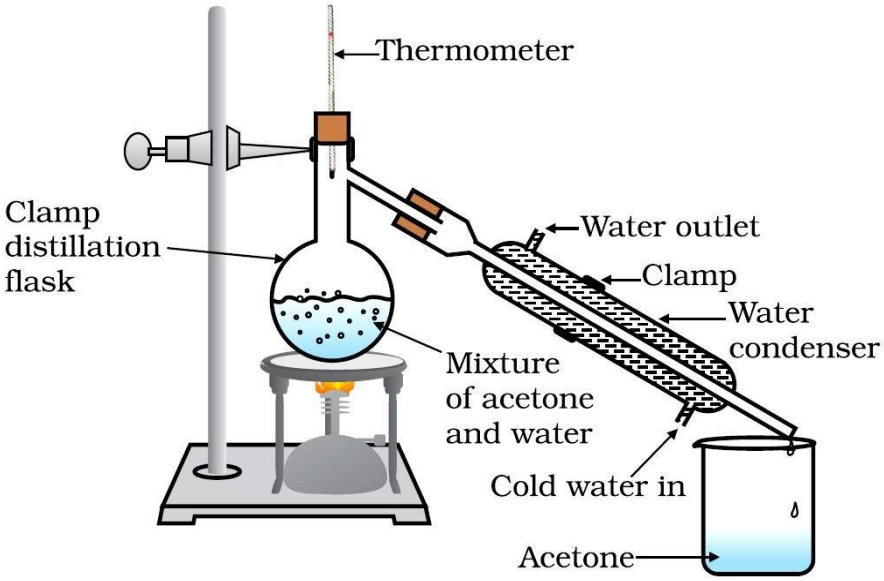


Application of chromatography -

- In the separation of colours from a dyes.
- In the separation of pigments from natural colours.
- In the separation of drugs from blood for pathological tests.

DISTILLATION

The process of distillation is used to separate two miscible liquids. The technique of distillation is based on the difference in boiling points of components of mixture of miscible liquids. Distillation is to separate the liquids which do not decompose even upto their boiling points



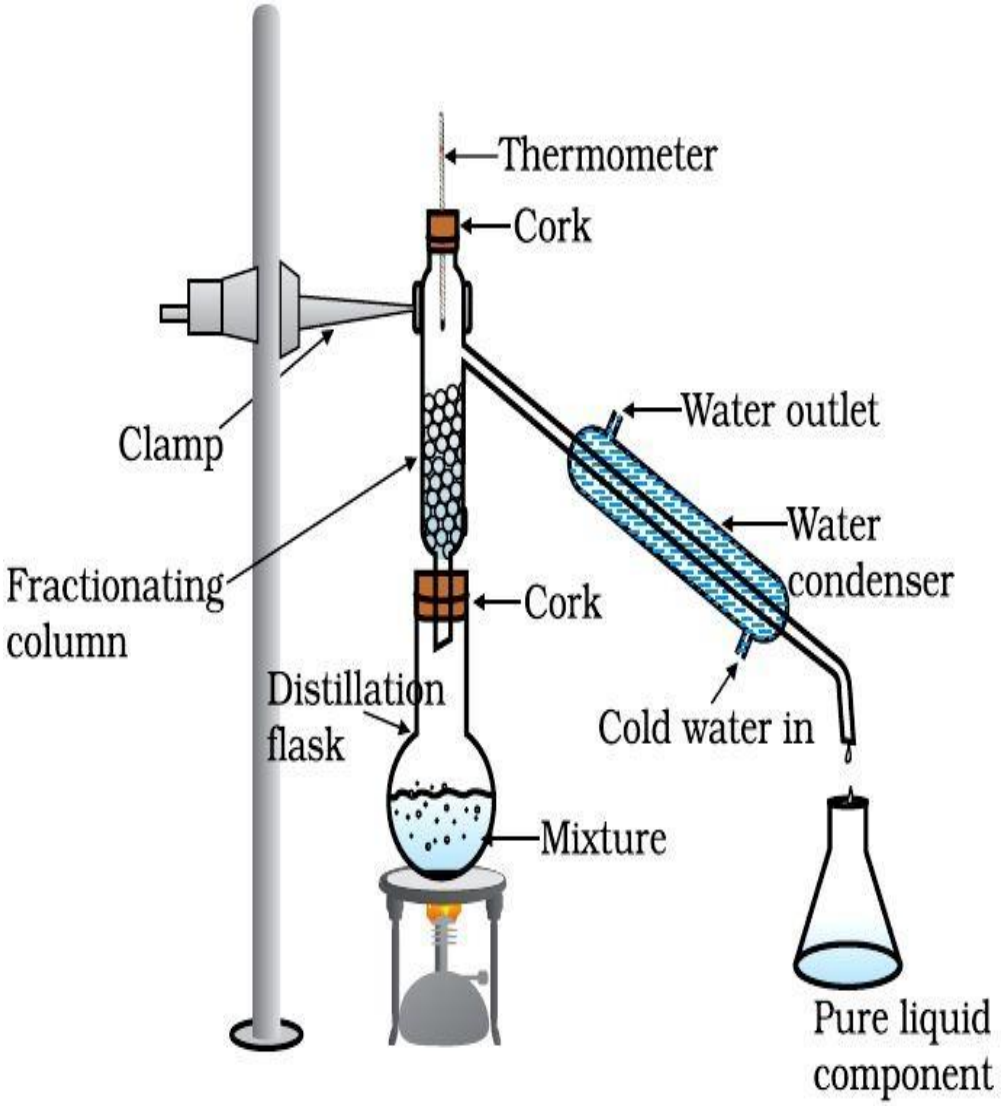
and should boil at more than 25^0C.

In the process of distillation, the mixture is heated after keeping in a retort or distillation flask. The liquid which boils at lower temperature is vaporized at lower temperature. The vapour so obtained is passed through a tube and gets condensed in a separate container; leaving liquid with higher boiling point in the retort or distillation flask.

Distillation is used to separate the components of the mixture of two miscible liquids that boils without decomposition and have sufficient difference in their boiling points.

The process of distillation is used to purify many liquids, such as water.

FRACTIONAL DISTILLATION



Fractional distillation is the process of separation of components of mixture into parts or fraction on the basis of fractional differences in their boiling points.

Fractional distillation is done when the difference in boiling points of the components of miscible liquids is less than 25^0C. In the process of fractional distillation, a fractional column is used along with retort or distillation flask.

Fractional column is a tube which contains glass beads, which facilitate surface for the vapour to cool and condense repeatedly.

Example – Ethanol and water are separated from their mixture using fractional distillation. The boiling point of water is 100^0C while the boiling point of ethanol is 78.4^0C. Since the difference of their boiling point is less than 25^0C, thus they are separated using fractional distillation.

Some of the Applications of Fractional Distillation:

- In petroleum refineries, petrochemical and chemical plants, natural gas processing and cryogenic air separation plants.
- In oil refineries to separate crude oil into useful substances (or fractions).
- In the process of organic juice.
- In the separation of oxygen, liquid nitrogen and argon from air.

SEPARATION OF DIFFERENT GASES FROM AIR

Air comprises of nitrogen, oxygen, carbon dioxide and argon as major components. Since air is the cheapest source of these gases, thus these are extracted from air at large scale

After liquefaction of air by repeated compression and cooling; nitrogen, oxygen, carbon dioxide and argon are extracted using fractional distillation.

Liquid nitrogen has boiling point equal to - 190^0C and thus turns into gas first and separated from air.

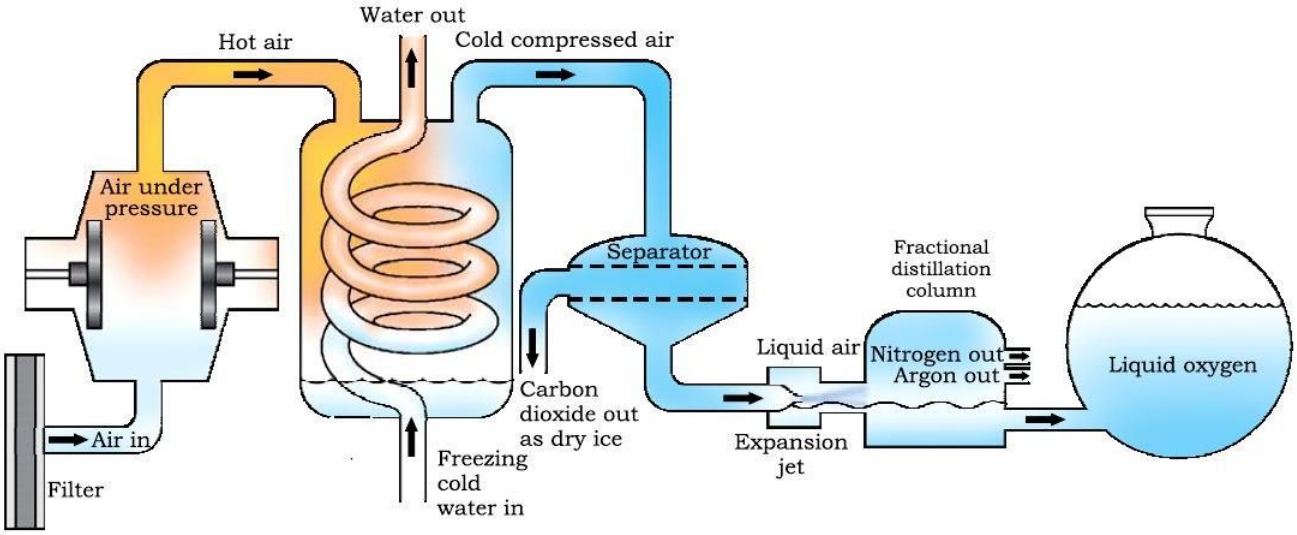
The boiling point of argon is - 186^0C, therefore it is extracted after argon.

The boiling point of oxygen is - 183^0C, thus it is collected after the extraction of argon.

Carbon dioxide turns into solid at a temperature of - 97^0C, therefore, it is removed while air is put under liquefaction.

USE

Nitrogen is used as fertilizers, oxygen is used in hospitals and argon is used in bulbs.



Separation of components of air

CRYSTALLIZATION

Crystallisation is a process that separates a pure solid in the form of its crystals from a solution. The crystallisation method is used to purify solids. For example, the salt we get from sea water can have many impurities in it. To remove these impurities, the process of crystallisation is used.

Crystallisation technique is better than simple evaporation technique as –

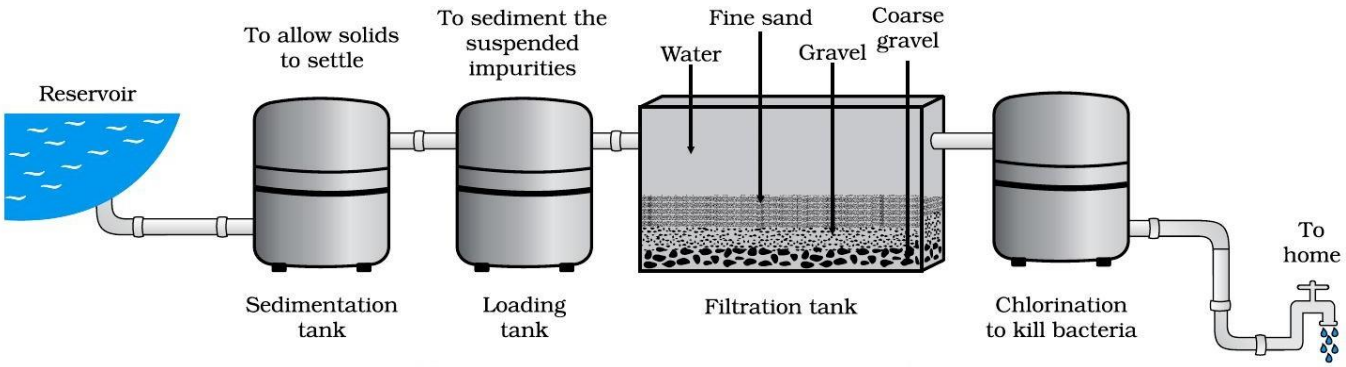
- some solids decompose or some, like sugar, may get charred on heating to dryness.
- some impurities may remain dissolved in the solution even after filtration. On evaporation these contaminate the solid.

APPLICATIONS

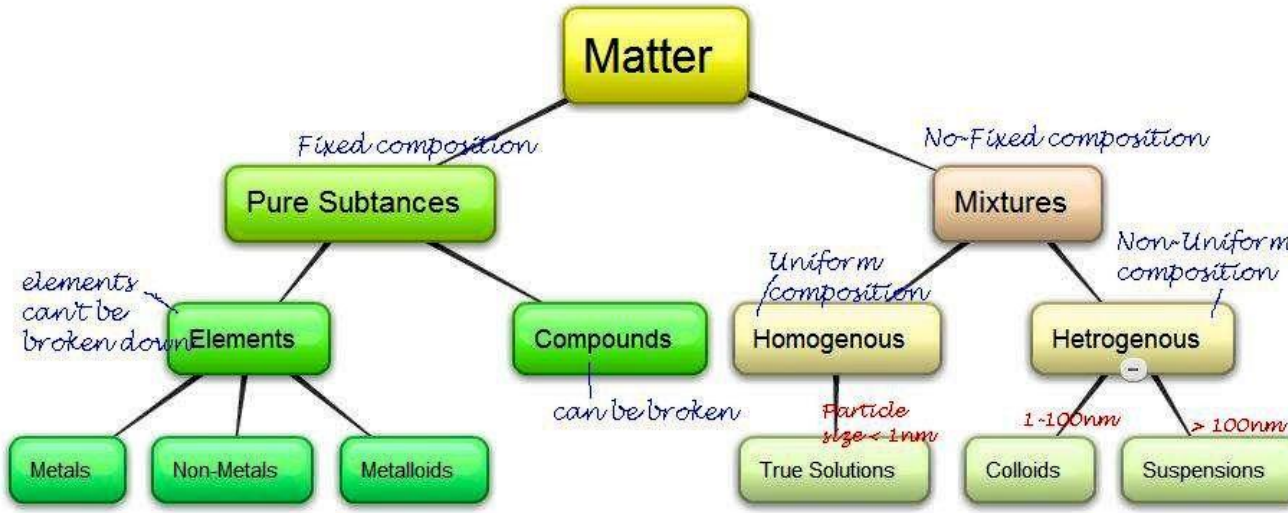
- Purification of salt that we get from sea water.
- Separation of crystals of alum (*phitkari*) from impure samples.

Thus, by choosing one of the above methods according to the nature of the components of a mixture, we get a pure substance. With advancements in technology many more methods of separation techniques have been devised.

In cities, drinking water is supplied from water works. A flow diagram of a typical water works is shown in below figure. From this figure write down the processes involved to get the supply of drinking water to your home from the water works and discuss it in your class.



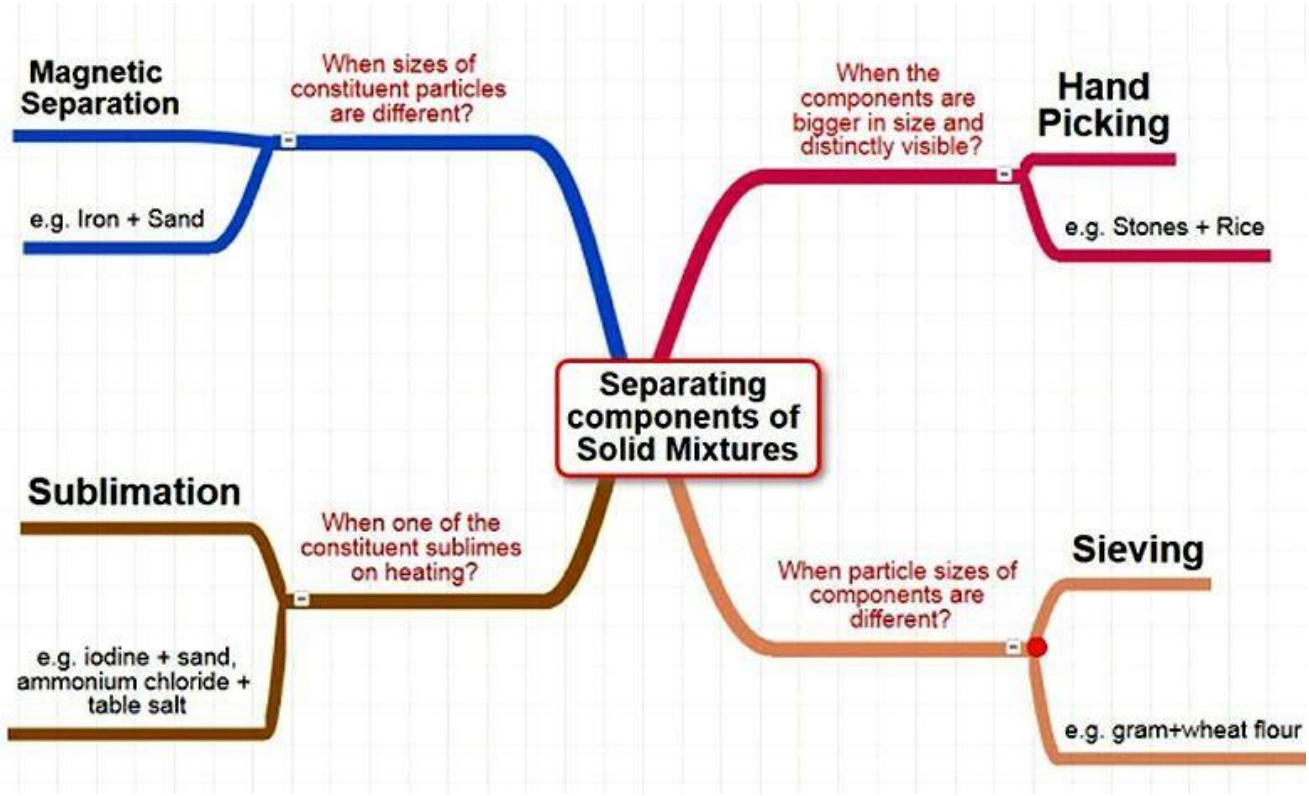
Water purification system in water works



DIFFERENT WAYS TO SEPARATE SOLID MIXTURES

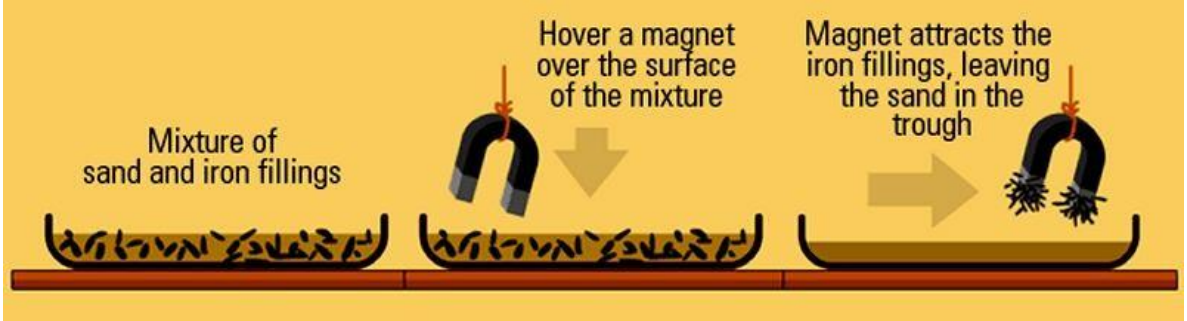
- Hand Picking
- Sieving
- Magnetic Separation Method

- Sublimation



MAGNETIC SEPARATION METHOD

Magnetic Separation Method is ideal for separating mixtures of two solids with one part having **magnetic** properties. Some metals like iron, nickel and cobalt have magnetic properties whiles gold, silver and aluminum do not. Magnetic elements are attracted to a magnet.



It works like this: Let us take a mixture of sand and iron filing for example.

To separate this, spread out the mixture on a flat surface. Run a magnet bar over the surface. You will notice that the magnetic elements (iron filings) will be attracted to the magnet over it. After a number of runs, all the sand will be free from any iron filing.

SIEVING METHOD

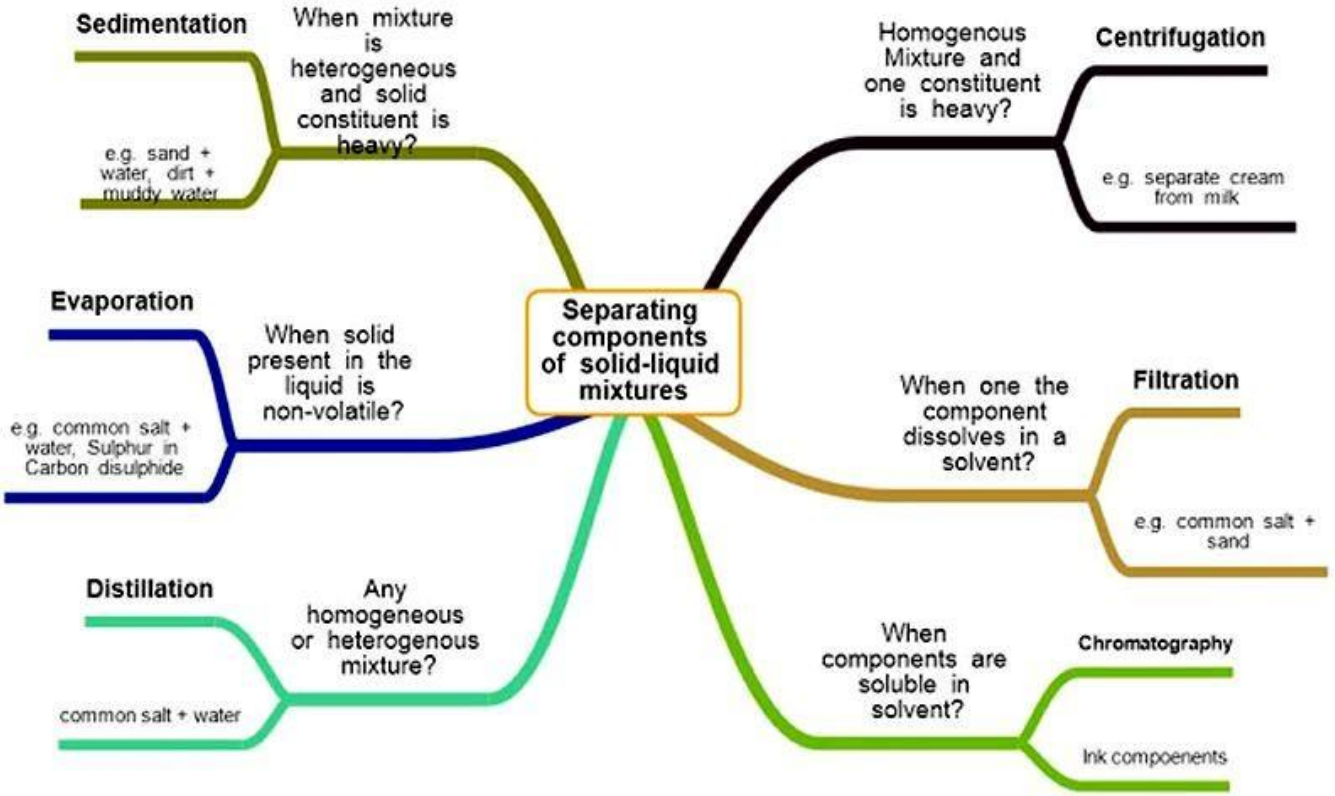
When the sizes of the components of a mixture are big enough, they can be separated with the help of sieve. A sieve is a simple mechanical device in which a mesh is attached to a frame. When the mixture is placed on the mesh and is stirred, particles of smaller size pass through the mesh while the bigger particles of the other component remain above the mesh.

E.g. gram can be separated wheat, sieving of sand at construction site etc.

HAND PICKING METHOD

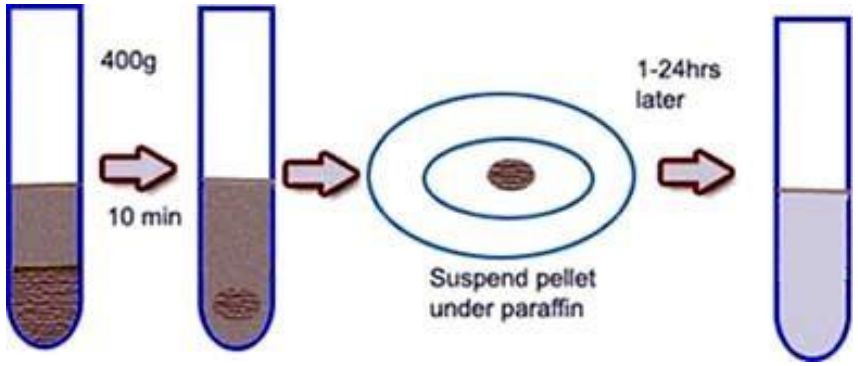
It involves simply picking out substances by hand and separating them from others. The substances being separated may be impurities that have to be thrown away or it may be that both the substances being separated are useful – such as if you separate green grapes from black ones from a mixture of the two.

DIFFERENT WAYS TO SEPARATE SOLID-LIQUID MIXTURES



SEDIMENTATION METHOD

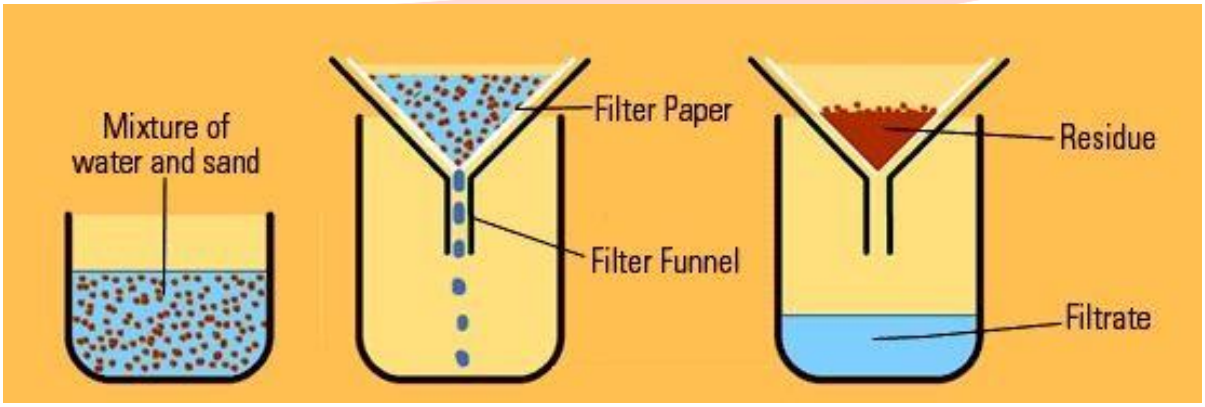
Sedimentation is the tendency for particles in suspension to settle out of the fluid in which they are entrained and come to rest against a barrier. This is due to their motion through the fluid in response to the forces acting on them: these forces can be due to gravity, centrifugal acceleration, or electromagnetism. In geology, sedimentation is often used as the opposite of erosion, i.e., the terminal end of sediment transport. In that sense, it includes the termination of transport by saltation or true bedload transport. Settling is the falling of suspended particles through the liquid, whereas sedimentation is the termination of the settling process.



FILTRATION METHOD

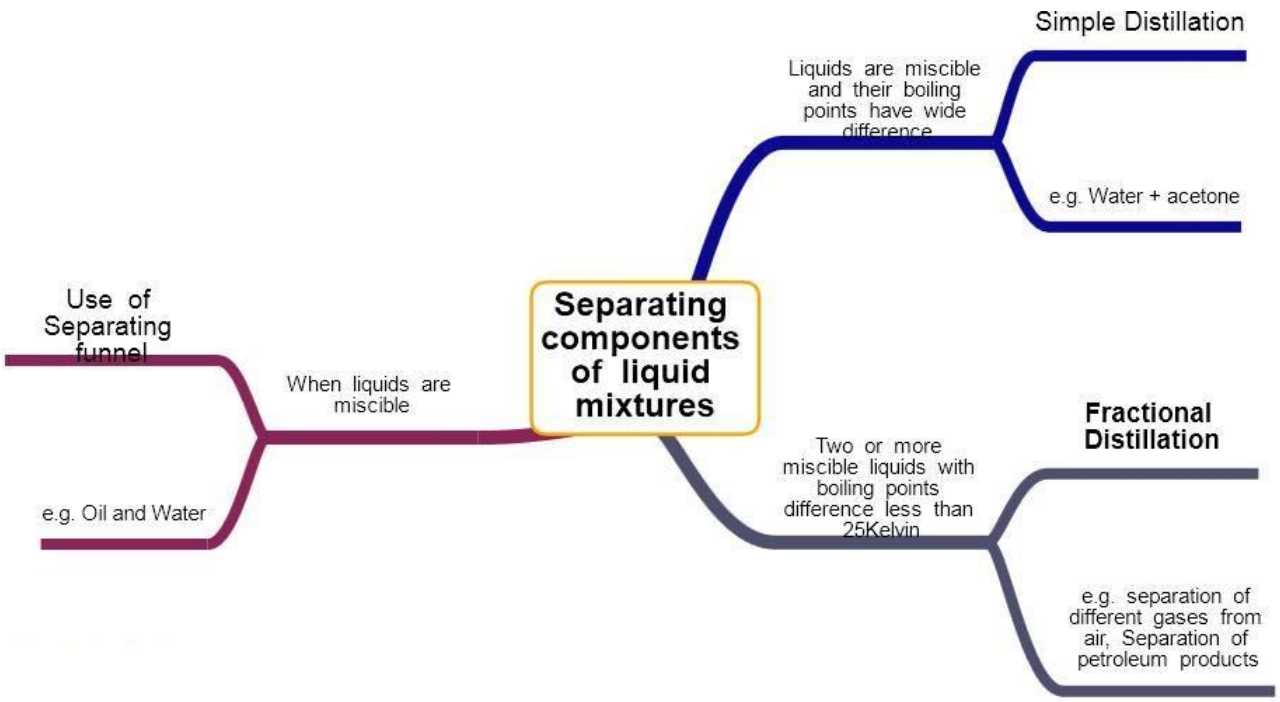
This is a more common method of separating an insoluble solid from a liquid. An example of such a mixture is sand and water. Filtration is used in water treatment plants, where water from the river is filtered to remove solid particles.

Here is a basic lab setup for filtration:



This process involves the use of a filter paper placed in a filter funnel. The funnel is placed in a beaker and the mixture of water and sand is poured into the funnel. The liquid part drains through the filter paper into the beaker, leaving the solid sand particles trapped on the filter. In filtration, the liquid part collected is called the filtrate and the solid bit that remained on the filter paper is called the residue.

DIFFERENT WAYS TO SEPARATE LIQUID-LIQUID MIXTURES



- Fractional distillation is the process of separating two or more miscible liquids by a modified distillation process, in which the distillates are collected as fractions having different boiling points. The separation of the liquids by this method is based on the difference in their boiling points.
- Fractional distillation makes use of a fractionating column or distillation column, a tube which provides different temperature zones inside it during distillation, the temperature decreasing from bottom to top. It provides surfaces on which condensations (of less volatile liquids) and vaporizations (of more volatile liquids) can occur before the vapours enter the condenser in order to concentrate the more volatile liquid in the first fractions and the less volatile components in the later fractions.
- Fractional distillation is very effective is separating mixtures of volatile components, and iswidely used in laboratories and industries.